



# Armed Forces College of Medicine (AFCM)

## Histology Department



# Red Blood Cells

**Ass. Prof. Dr. Samaa Kamar**

# Intended Learning Objectives (ILO)



**By the end of this lecture the student should**  
**be able to:**

- **Correlate** the structure of RBCs to its function.
- **Interpret** the defective structure of the RBC in different diseases.

# Lecture Plan



- 1. Part 1 (3 min): Introduction to blood elements**
- 2. Part 2 (40 min): RBCs structure and function**
- 3. Part 3 (3 min): Summary**
- 4. Lecture Quiz (4 min)**



# Blood

- = A special type of connective tissue in which the matrix is fluid (plasma).
- Average volume in adult : 5 liters

## Components of blood

### Plasma

1- Water (92% of plasma)

2- Proteins

3- Others:

(Electrolytes,  
Nutrients, Respiratory  
gases, Waste)

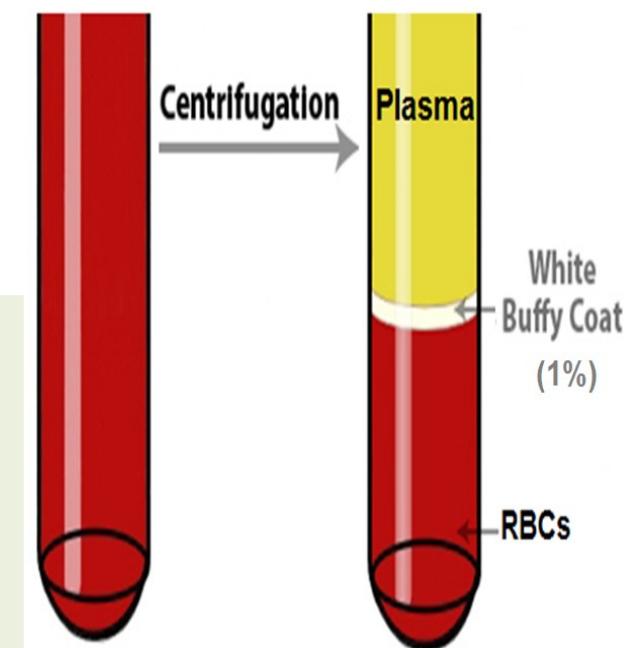
### Blood elements 45%

1- Red blood corpuscles (RBCs) =

Erythrocytes

2- White blood cells (WBCs) =

Leucocytes



# Red Blood Corpuscles (Erythrocytes)



**Origin:** Stem cells in red bone marrow

**Number**

**Shape:**

**Size**

**Color**

**Structure**

**Function**

**Life span**

**Normal & Abnormal**



# RBCs



## Number (count):

The number of erythrocytes/cubic millimeter of blood.

- Male:                    5-5.5  
million/mm<sup>3</sup>
- Female:                4.5-5  
million/mm<sup>3</sup>



## Less in females due to:

1. Monthly blood loss with **menstruation**.
2. Inhibitory effect of **female hormones** on the

# Abnormal Number

- o **Polycythemia** ( **+++ 6.5 million in males; 6 millions in females** ):

**Physiological:** High altitude, newborn

**Pathological:** Chronic heart/ respiratory disease .... Hypoxia  
Renal cell carcinoma ..... Increased erythropoietin

**Relative Polycythemia:** increased RBCs count due to decreased plasma volume

ex. Dehydration

- o **Oligocytosis** ( **↓ 4 millions in F** ):

**“Anemia”**

**Decrease in RBCs count &/or ↓ Hb concentration**



# RBCs

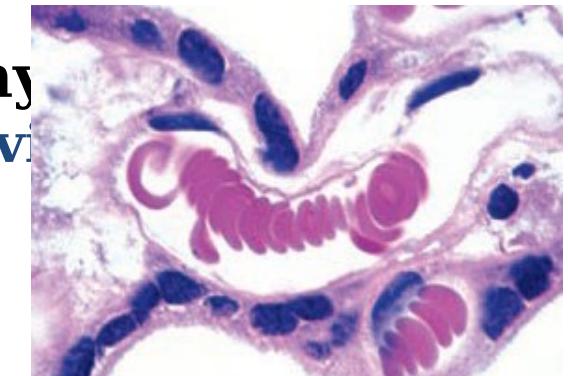
**Shape:**

- Top view: Rounded
- Side view: **Biconcave disc**



**“Rouleau appearance”:** stacks of coins

(in: small vessels, multiple my  
(in areas with low velocity and high v



The stability of the biconcave shape is  
due to

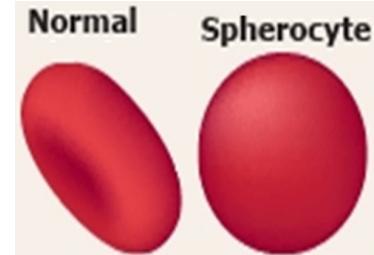
Presence of special peripheral cytoskeleton  
formed of

- Provide actin filaments bond to **spectrin** and increase surface area for **ankyrin proteins**
- Places most of Hb in contact with the cell surface to facilitate gas exchange.

# Abnormal shape of RBCs

## “Poikilocytosis”

- **Spherocytosis:** spherical erythrocytes due to abnormal cytoskeleton.



- **Spherocytosis**: They all can't adapt to changes in their environment (e.g., osmotic pressure and mechanical deformities), which results in hemolysis



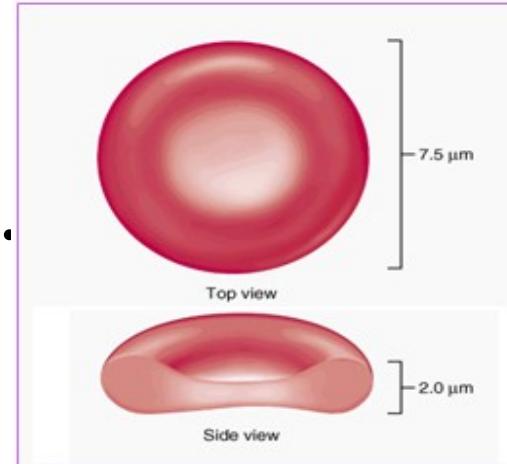
# RBCs



## Size:

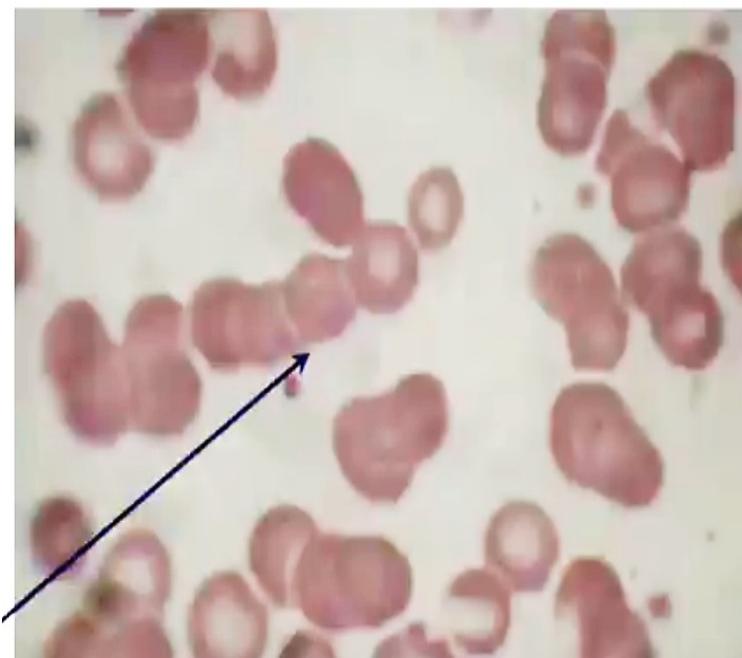
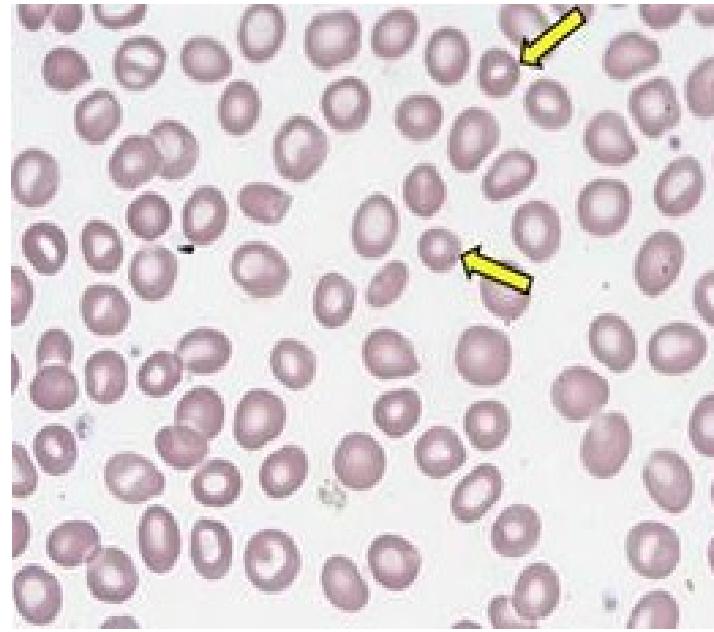
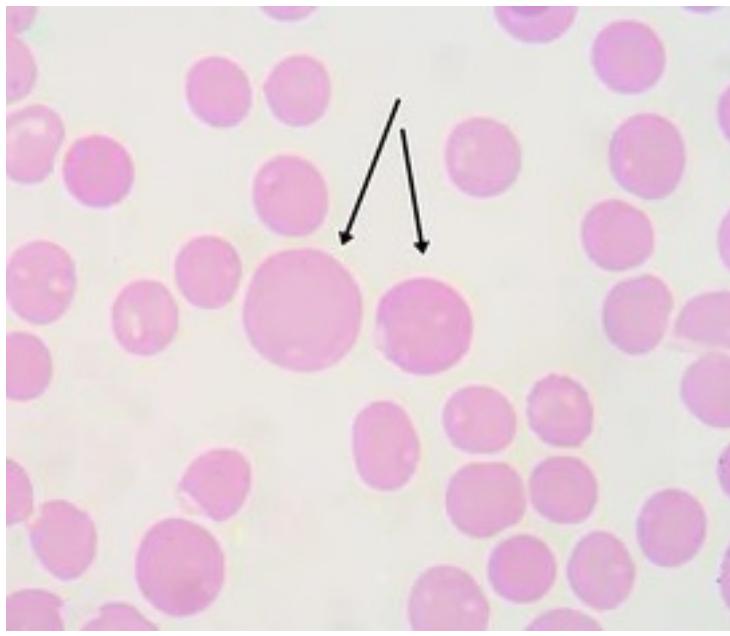
- Diameter: average **7.5 µm**.
- Thickness: about **2.6 µm (periphery)** & **0.7 µm (center)**.

**(center) RBCs with normal size = Normocytes**



## Abnormal Size

- **Diameter  $> 9 \mu\text{m}$  = Macrocye**
- **Diameter  $< 6 \mu\text{m}$  = Microcyte**
- **Different sizes = Anisocytosis**



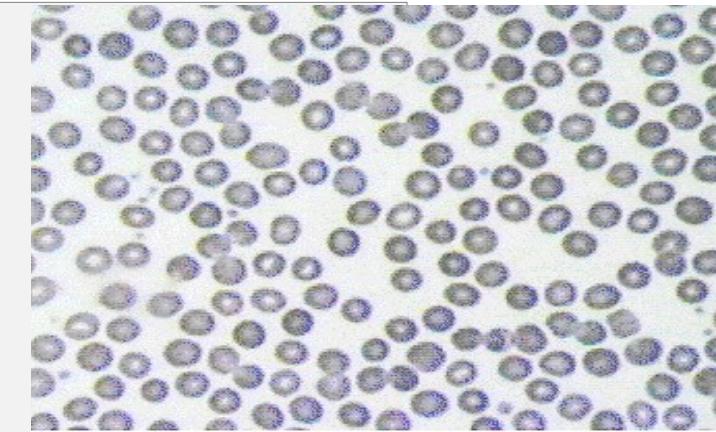


# RBCs

**Color:**

## Unstained RBCs:

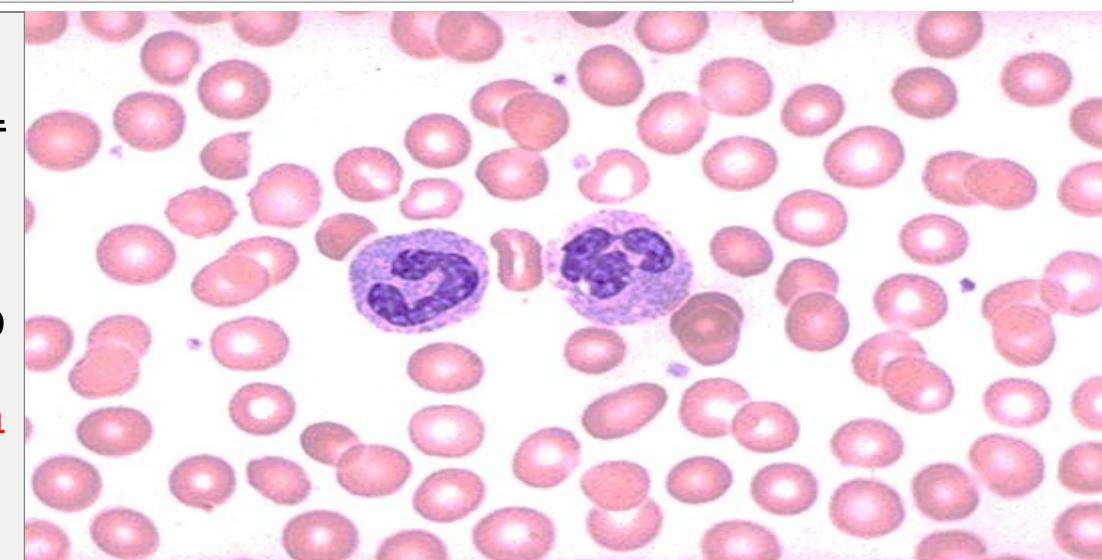
- Single cell: greenish yellow condition.
- Grouped cells: red in color (due to their hemoglobin pigment content)



Blood%20Cells%20%20A%20P%0%5BPDF%5D%5BUnitedVRG

## Stained “Blood film” with leishamn’s stain:

RBCs appear acidophilic (because of Hb is protein) with a pale central area (=Normochromic) about 1/3 of its diameter.

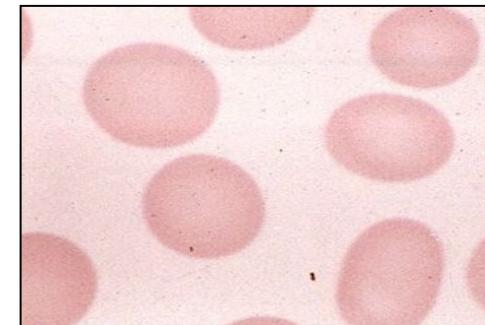


# Abnormal Color

**Normal Hb:** 14-18g/dl in males & 12-16g/dl in females.

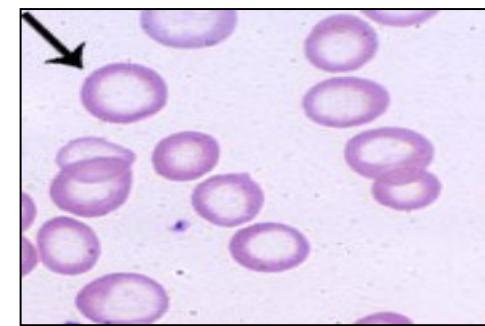
More Hb content than normal

- o **Hyperchromic** **stained central area** & a more deeply stained periphery

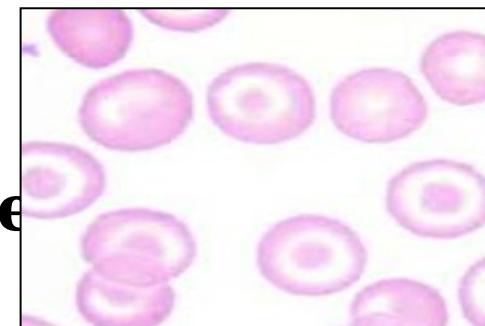


Less Hb content than normal

- o **Hypochromic** **Larger pale central area** and pale staining periphery.



- o **Target cell** (Hb at the center with pale periphery)  
(in Hb abnormality, thalassemia, live)

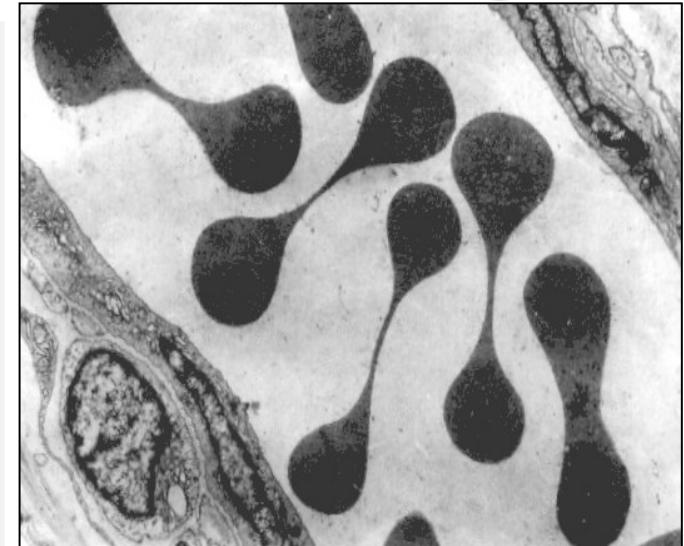




# RBCs

## Structure:

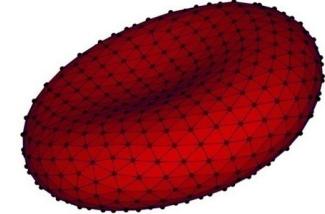
- Bag of Hb surrounded by plasma membrane.
- They lack nucleus, mitochondria and organelles giving a space for the Hb inside them.



**Hemoglobin is O<sub>2</sub>-carrying protein**

## ❖ Molecular structure of the plasma membrane

~~of erythrocyte~~ **lipid bilayer** that contains **2 groups of proteins**



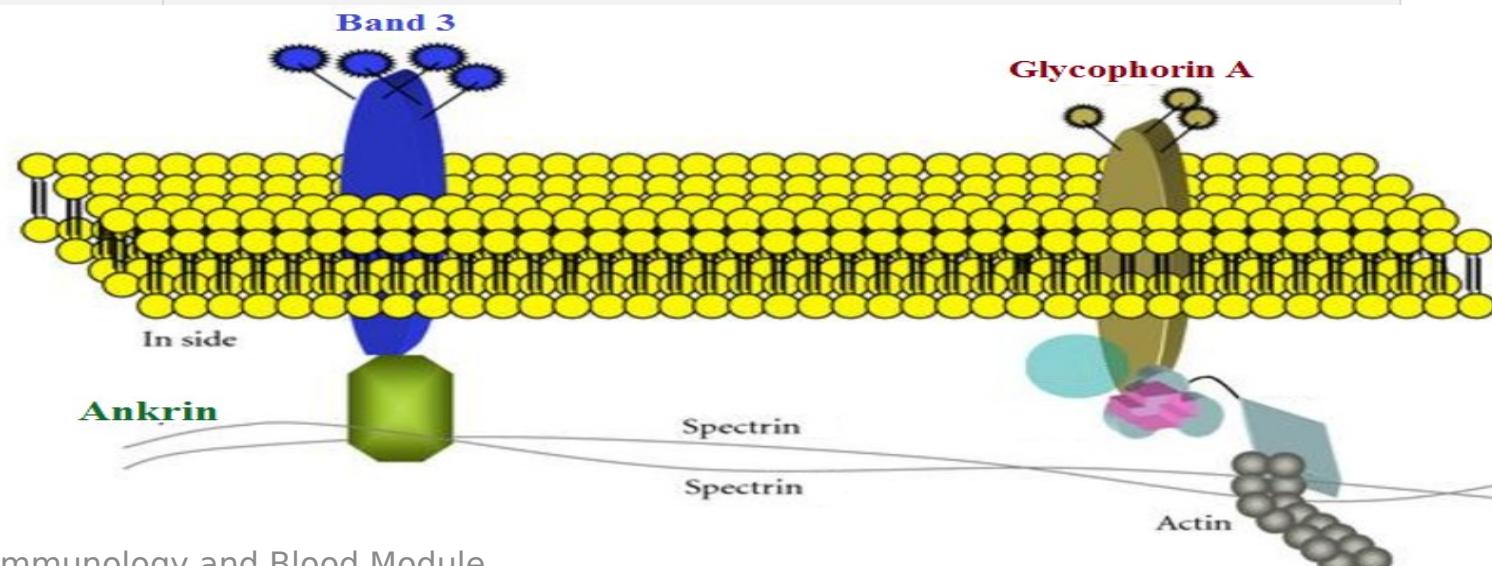
### Intrinsic “transmembrane” proteins

- Ion channels
- Band 3 protein: binds Hb and ankrin

They have extracellular glycosylated parts that form the antigenic sites responsible for **ABO blood typing**

### Peripheral proteins (on inner surface):

- Spectrin (form a network that bind to Actin)
- Ankyrin which anchors the



# The unique structure of the plasma membrane of the erythrocytes maintains:

- 1- The biconcave shape of erythrocytes.**
- 2- The flexibility of RBCs with round edges** that enables them to change their shape inside narrow capillaries then regain their shape in wider vessels.
- 3- Its selective permeability** to ions and gases.
- 4- Easy accessibility of Hemoglobin to oxygen.**

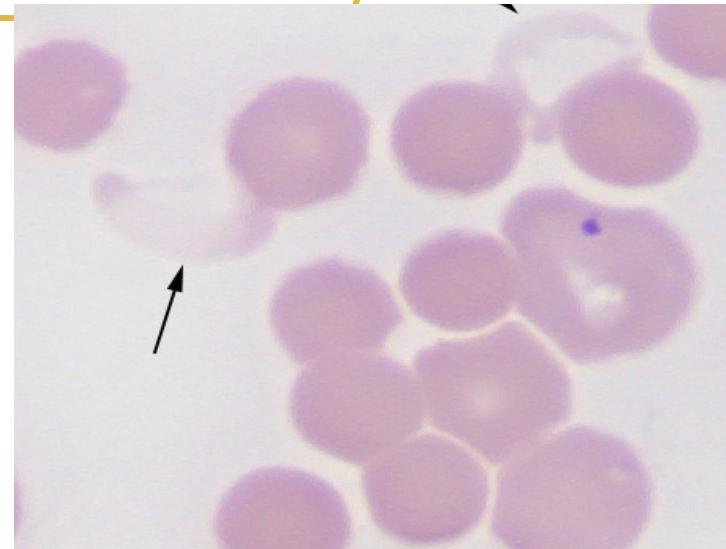


# Plasma membrane permeability

If blood is added to hypotonic solution



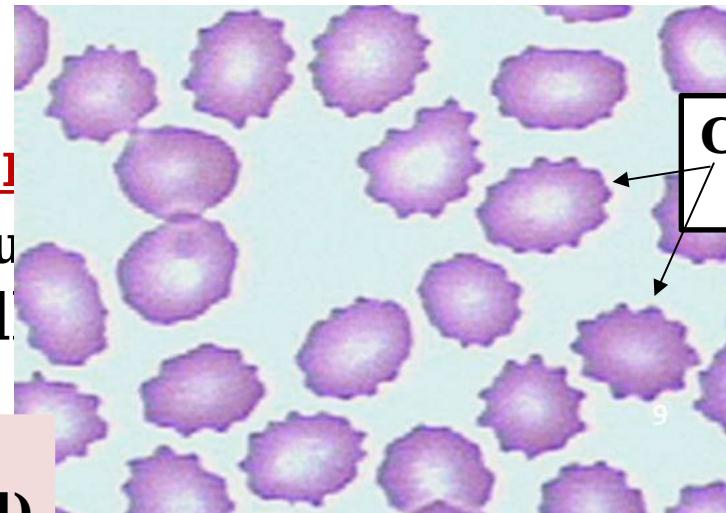
Hemolysis



If blood is added to hypertonic solution



“Crenation” = Undulated surface  
“Echinocyte = Burr cell”



Artifact or uremia  
(high level of nitrogen waste products in the blood)

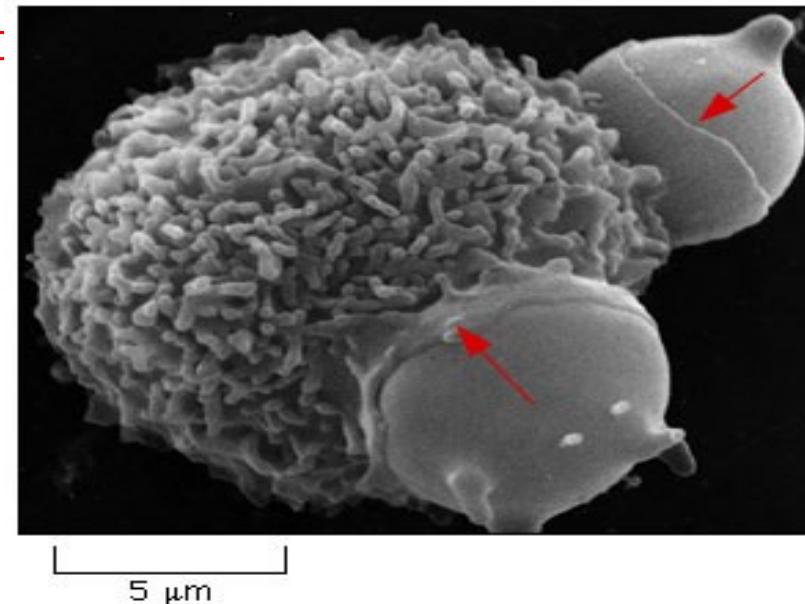
<https://www.pinterest.com/pin/381680137149148314/?lp=true>

# RBCs



**Life span:**

- About 120 days
- Then, they become fragile and fragmented when passing through narrow vessels.
- The fragments are phagocytosed and removed by macrophages.



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# **Adaptation of erythrocytes' structure to their function**

- 1- Absence of nucleus and organelles give more space for Hb.**
- 2- The biconcave shape of erythrocytes:**
  - a. Provides a large surface area/volume ratio to increase surface area for gas exchange**
  - b. Places most of Hb in contact with the cell surface to facilitate gas exchange**
- 3-The flexibility of RBCs with round edges enable them to pass through narrow capillaries.**
- 4- Plasma membrane of erythrocytes prevents the escape of hemoglobin to plasma.**

# **Clinical Correlation**

# Anemia

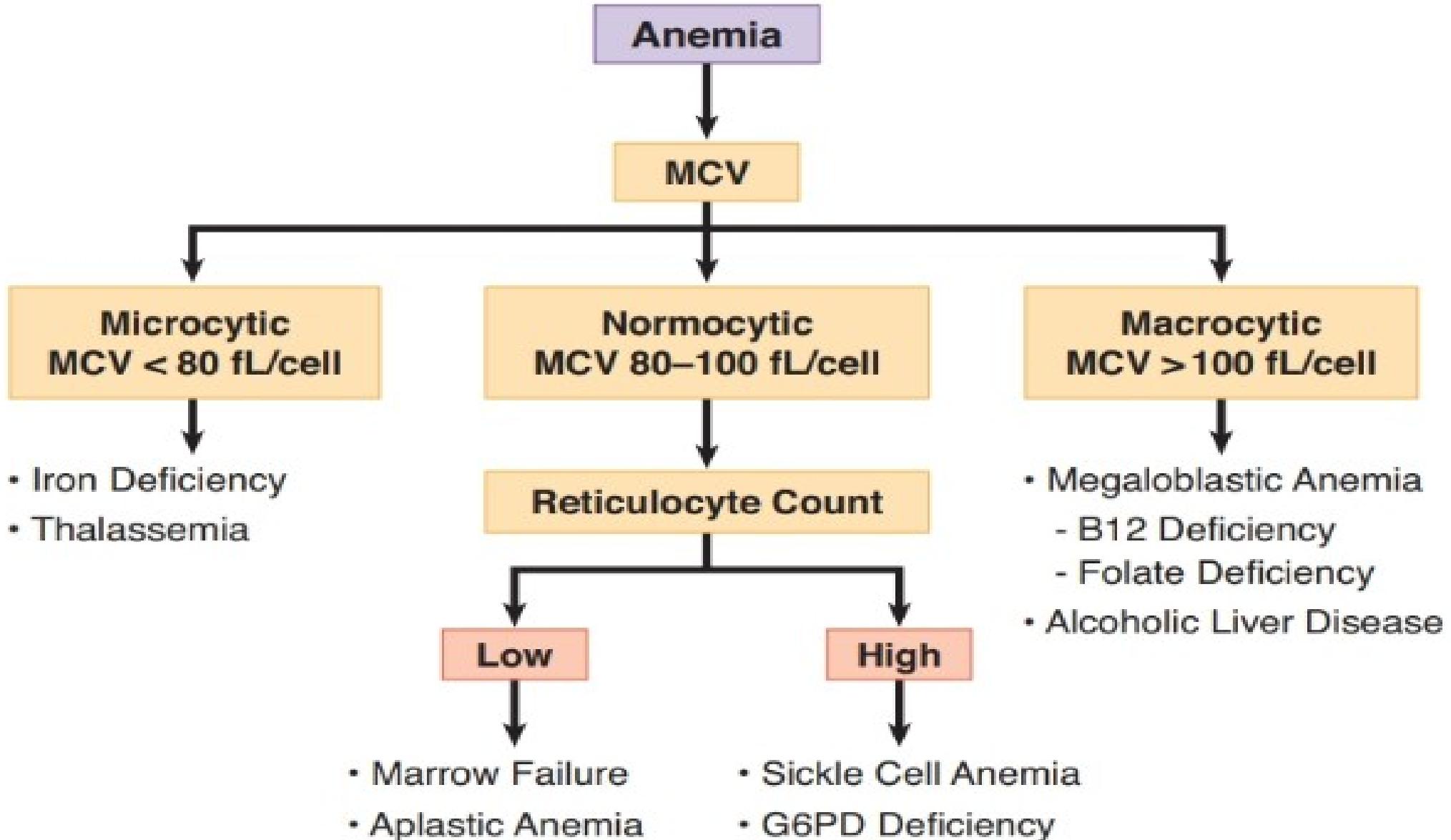


**Classification of anemia can be based on**

**I. Color:**

- a. **Normochromic A.: normal color (central pallor =  $\frac{1}{3}$  of the diameter).**
- b. **Hypochromic A.: decreased color (increased the central pallor).**
- c. **Hyperchromic A.: have increased color (loss of central pallor).**

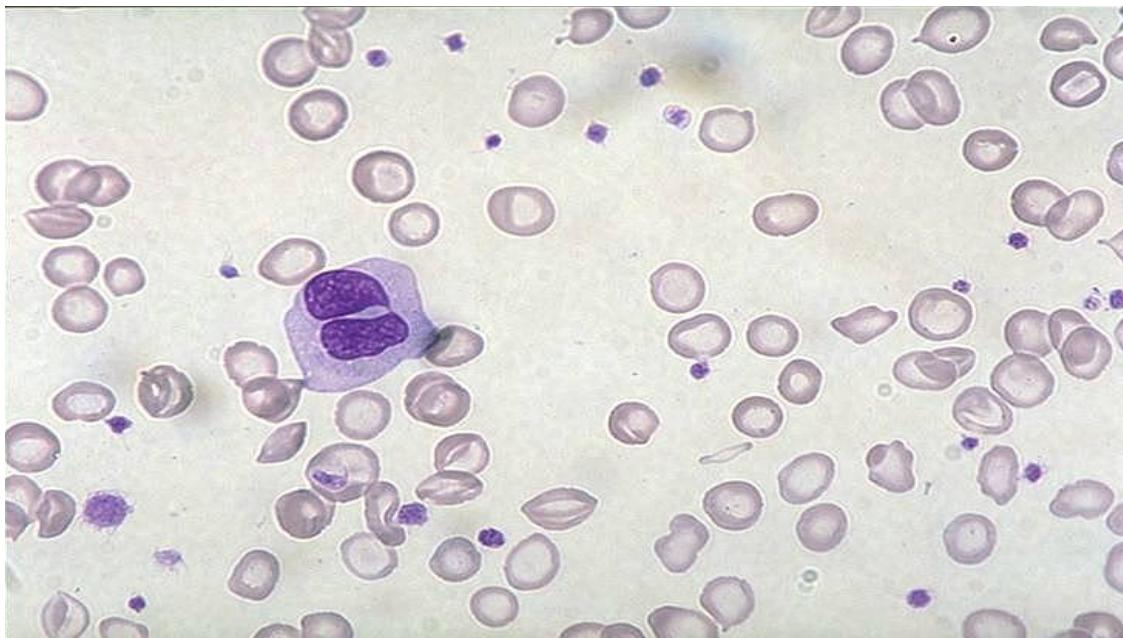
**II. Mean Corpuscular Volume (MCV):**





# Anemia

**Microcytic hypochromic**  
ex. Iron deficiency anemia  
Thalassemia



[https://www.pathpedia.com/education/eatlas/histopathology/blood\\_cells/anemia\\_-\\_iron\\_deficiency.aspx](https://www.pathpedia.com/education/eatlas/histopathology/blood_cells/anemia_-_iron_deficiency.aspx)

**Macrocytic /megaloblastic**

ex. Deficiency of Vit B12  
(Pernicious a.)

Deficiency of folic acid  
impaired DNA synthesis (delayed mitosis)



<https://www.pathologystudent.com/anemia-quiz/hypersegmented-neutrophil-2/>

# **Summary**

# RBCs (Erythrocytes)



**Origin:** Stem cells in red bone marrow

**Number:** about 5 million/mm<sup>3</sup> (the most abundant blood component)

**Shape:** flexible, biconcave disc / “Rouleau” / spectrin & ankrin.

**Size:** about 7.5 µm in diameter / 2 µm & 0.5 µm thickness.

**Color:** acidophilic with a pale central area (about 1/3).

**Structure:** transmembrane proteins; glycophorin A & band 3 protein form the basis for the ABO blood typing.

**Function:** contains O<sub>2</sub>-carrying protein hemoglobin

**Life span:** 120 days / removed by macrophage of liver, spleen & BM.

# Quiz



## **Red blood cells are characterized by**

- a. Biconcave shape
- b. Small pyknotic nucleus
- c. Having a diameter 12  $\mu\text{m}$
- d. Inflexible cytoskeleton
- e. Undifferentiating.

## **In structural adaptation of RBCs, there is**

- a. Free ribosomes for protein synthesis.
- b. Mitochondria for energy production.
- c. Rounded shape for easy passage of oxygen.
- d. Biconcave flexible shape to pass through narrow capillaries.
- e. Numerous organelles.

**Which component of the erythrocyte cell surface is responsible for determining blood type (the A-B-O system)?**

- a. Fatty acid
- b. Carbohydrate
- c. Nucleic acid
- d. Protein
- e. Cholesterol

**What is the approximate life span of a circulating erythrocyte?**

- a. 8 days
- b. 20 days
- c. 5 weeks
- d. 4 months
- e. 1 year

**For a laboratory blood test, fresh blood sample is drawn and centrifuged in the presence of heparin as an anticoagulant to obtain a hematocrit. From top to bottom, the fractions resulting from centrifugation are which of the following?**

- a. Serum, packed erythrocytes, and leukocytes
- b. Leukocytes, erythrocytes, and serum proteins
- c. Plasma, buffy coat, and packed erythrocytes
- d. Fibrinogen, platelets, buffy coat, and erythrocytes
- e. Albumin, plasma lipoproteins, and erythrocytes

# Quiz



**Match the following expressions with their meaning**

**1-Oligocythemia**

a.Increased number of RBCs

**2-Poikilocytosis**

b. Variation in size of RBCs

**3- Polycythemia**

c. Decreased number of RBCs

**4- Anisocytosis**

d. Variation in shapes of RBCs

# Quiz



**e reasons:  
RBCs are biconcave?**

- a. Provides a large surface area/volume ratio to increase surface area for gas exchange.

**ABO types of RBCs?**

- b. Places most of Hb in contact with the cell surface to facilitate

gas exchange.

They have transmembrane proteins, glycophorin A & band 3 protein, that display extracellular glycosylated parts that form the antigenic sites responsible for ABO blood typing.

**Mechanical stability and flexibility of RBCs?**

Presence of special peripheral cytoskeleton formed of actin filaments bond to spectrin and ankyrin proteins.

# Suggested textbooks



- 1. Junqueira`s Basic Histology; Text and Atlas. 14<sup>th</sup> edition 2016.**
- 2. Histology atlas and test: Michael H. Ross and Wojciech Pawlina, 7<sup>th</sup> edition, 2015.**



Thank  
you

